Deep venous thrombosis after percutaneous insertion of vena caval filters

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Purpose: **A large multicenter study has recently questioned the overall clinical efficacy of vena caval filters, especially when inserted prophylactically, because of the subsequent development of deep venous thrombosis (DVT) at the insertion site. We examined the incidence of this complication with newer, smaller diameter percutaneous devices.**
Methods: **We reviewed our vascular surgery and interventional radiology clinical registries to identify patients in whom a femoral percutaneous vena caval filter had been placed from 1993 to 1998. This list was cross referenced with patients who had undergone lower extremity venous ultrasound scan examinations for the diagnosis of DVT in the vascular laboratory within a 60-day period before and after the insertion of the filter device.**
Results: **A total of 35 patients during this 5-year period had timely follow-up venous duplex scan studies performed. The indications for filter placement were DVT in 16 patients (46%), pulmonary embolus in 13 patients (37%), DVT and pulmonary embolus in three patients (9%), and prophylactically in three patients (9%) at high risk for thromboembolization. Of the patients with documented thromboembolic events, 91% (29 of 32) had contraindications to anticoagulation therapy, and the remaining 9% (3 of 32) represented failure of anticoagulation therapy. A Greenfield filter was used in 13 patients (37%), a Simon Nitinol filter was used in 11 patients (31%), and a VenaTech filter was used in nine patients (26%). The other two patients (6%) had a Bird's Nest filter inserted. At a mean follow-up period of 12 ± 2 days (median, 6 days), there was a 40% (14 of 35) incidence of proximal DVT in venous segments without evidence of thrombus before filter insertion. The majority (71%; 10 of 14) occurred in the common femoral vein, with three located in the superficial femoral vein and one in the external iliac vein. The lowest incidence of DVT was seen with the Greenfield and Bird's Nest filters as compared with the smaller Simon Nitinol and VenaTech filters (20% vs 55%; $P < .05$). The highest incidence of thrombosis occurred in patients with pre-insertion pulmonary emboli (50%; 8 of 16) as compared with those patients with DVT (38%; 6 of 16) and prophylactic insertion (0%; 0 of 3). However, the subgroups were too small to attain statistical significance.**
Conclusion: **There is a continuing and significant incidence of new DVT development ipsilateral to the percutaneous femoral insertion site of vena caval filters. The smaller diameter filters are not associated with a lower incidence of femoral thrombosis. (J Vasc Surg 1999;30:821-9.)**

Vena caval filters have been demonstrated to be effective in the long-term prevention of pulmonary embolization (PE). The incidence of PE with the Greenfield filter has been reported to be only 3% in patients followed for more than 20 years, and caval patency is maintained in more than 95% of the patients.[1,2] The introduction of smaller diameter delivery systems has made possible the percutaneous placement of these filters. With progressive diminution in their size and greater ease of insertion, there have been calls for their increased use, especially prophylactically in trauma patients at high risk.[3] A recent multicenter study, however, has questioned the overall clinical efficacy of vena caval filters because of the increased subsequent development of deep venous thrombosis (DVT) in the lower extremities.[4] This development was presumed to be partially the result of thrombosis initiated at the percutaneous insertion site. We reviewed our experi-

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Table I. Pre-insertion deep venous thrombosis location

Vein	*Right*	*Left*	*No.*
External iliac	1	2	3 (6%)
Common femoral	2	3	5 (11%)
Superficial femoral	2	9	11 (23%)
Popliteal	4	8	12 (26%)
Calf	5	6	11 (23%)
Superficial/GSV	2	3	5 (11%)
Total	16 (34%)	31 (66%)	47 (100%)

GSV, Greater saphenous vein.

ence with these filters to examine and compare the incidence of this complication with the newer, smaller diameter percutaneous devices.

PATIENTS AND METHODS

All the vena caval filter devices inserted at the Milton S. Hershey Medical Center of the Penn State Geisinger Health System are inserted either by members of the Sections of Vascular Surgery or Interventional Cardiovascular Radiology. We reviewed the computerized patient registries of these two clinical services to identify all patients in whom a femoral percutaneous vena caval filter had been placed between 1993 to 1998. This list then was cross referenced with the records of patients who had undergone lower extremity venous duplex ultrasound scan examinations for the diagnosis of DVT in the vascular laboratory within a 60-day period before and after the insertion of the filter device. Those patients who were identified to have fulfilled these requirements form the basis of this report.

The selection of a particular vena caval filter device for insertion was made on the basis of the personal preferences of the physician who performed the procedure. Vascular surgeons preferentially used the Greenfield stainless steel, over-the-wire filter (Meditech, Boston Scientific, Watertown, Mass). When the vena cava size exceeded 28 mm in diameter, a Bird's Nest filter (Cook Inc, Bloomington, Ind) was used. The other devices used included the VenaTech LGM (B Braun/VenaTech, Evanston, Ill) and the Simon Nitinol filter (Bard Radiology, Covington, Ga). Inferior vena caval angiography was performed in all patients before filter insertion to ascertain caval patency, diameter, and renal vein location. It was surgical protocol to obtain a follow-up duplex ultrasound scan of the lower extremities approximately 1 week after the procedure. Follow-up studies were not routinely obtained by the radiologic service. Details of filter placement were obtained from surgical operative notes and interventional radiology procedure notes. The indication for the procedure, the type of filter, the introducer size, the route of insertion, and complications during the procedure were recorded. The duration of sheath placement and the extent and duration of manual compression after sheath removal were not recorded. The computerized hospital laboratory information system (Powerchart, Cerner Corp, Kansas City, Mo) was used to examine the prothrombin time, the international normalized ratio, and the activated partial thromboplastin times for the 2 days after the insertion of the filter and on the day of the duplex scan follow-up examination as an indication of the anticoagulation status of the patients.

The duplex ultrasound scan examination records were reviewed for each patient. The indications for the examination, the presence and location of intraluminal thrombus, the characteristics of venous flow, distal augmentation, and compressibility of vessel walls with ultrasound scan probe compression were recorded for each venous segment from the external iliac vein to the tibial vessels.

The data were entered onto a spreadsheet (Excel 95, Microsoft, Redmond, Wash). The results are expressed as the mean ± the standard error of the mean. Statistical analysis was performed with the SigmaStat statistical program (Jandel Scientific, San Rafael, Calif). The Mann-Whitney rank sum test or the Student *t* test were used to compare continuous data. Either the Fischer exact test or the χ^2 test were used for dichotomous data. A two-tailed *P* value of less than .05 was considered to be statistically significant.

RESULTS

During the 5-year time period from November 27, 1993, to December 31, 1998, there were a total of 35 patients who fulfilled the inclusion criteria for this study. This represented 13% of all the 265 vena caval filters that were inserted during this time period. There were 23 male and 12 female patients. The mean age was 59 ± 3 years, with a range of 17 to 89 years and a median age of 60 years. Sixteen patients (46%) had proximal DVT (popliteal or more proximal veins), 13 patients (37%) had PE, three patients (9%) had both DVT and PE, and the remaining three patients (9%) were at high risk for thromboembolization. Of those patients with pre-insertion DVT, two thirds had DVT in the left leg. Half of the thrombi were located in the superficial femoral-popliteal venous segments (Table I). None of the thrombi were located in the common femoral or external iliac veins on the side of percutaneous

Table II. Indications for vena cava filter

	No. of patients
Contraindications to anticoagulation therapy	29 (83%)
Bleeding with anticoagulation therapy	6
Thrombocytopenia	4
Recent trauma/surgery	3
Pre-operative	3
Bleeding before anticoagulation therapy	2
Metastatic carcinoma	2
Warfarin failure	3 (9%)
Prophylaxis	3 (9%)
TOTAL	35

Table III. Vena cava filters

			Diameter (F)	
Filter type	*No. of filters*	*Metal type*	*Filter*	*Sheath*
Greenfield	13 (37%)			
Stainless steel	11	Stainless steel	12	15.6
Titanium	2	Titanium	12	14.3
Simon Nitinol	11 (31%)	Nickel-titanium	7	9.0
VenaTech	9 (26%)	Phynox	10	12.9
Bird's Nest	2 (6%)	Stainless steel	11	14.0
TOTAL	35			

Diameters listed are outer diameters of the filters and sheaths.

vena cava filter insertion. One patient had DVT in the superficial femoral vein, and three patients had popliteal venous involvement ipsilateral to the caval filter insertion site.

The most frequent indication for the placement of a vena caval filter was a contraindication to anticoagulation therapy in 29 patients, six of whom had had bleeding complications while undergoing such therapy (Table II). Anticoagulation therapy failure with warfarin was seen in three patients. These included two episodes of PE and one extension of DVT while undergoing warfarin therapy for proximal DVT. Prophylactic vena cava interruption was performed in the other three patients. One patient had a distant history of PE and was pending craniotomy for a glioblastoma, another had a subdural hematoma after trauma and was pending a hip replacement for an associated fracture, and the third patient had a proximal thrombus of the greater saphenous vein and was at continuing high thromboembolic risk because of traumatic head and pelvic injuries and was immobilized in bed. The mean time from the initial duplex scan diagnosis of DVT and vena caval interruption was 1.3 ± 0.5 days, with a range of 0 to 17 days and a median of 0 days.

Of the filters that were inserted, 28 (80%) were inserted by fellowship-trained interventional radiologists and the remaining seven (20%) were inserted by vascular surgeons. The surgical service inserted only the Greenfield stainless steel over-the-wire filters, and the radiologists inserted a variety of others (Table III). They were preferentially inserted via the right common femoral vein (31; 89%) unless monitoring catheters or recent trauma precluded this choice of insertion site (n = 3) or venous cannulation was technically unsuccessful, in which case the contralateral left femoral vein was used. The only periprocedural complications that were encountered were three initial incidental insertions of the 18-gauge finder needles into the femoral artery. These needles were withdrawn, and the vein thereafter successfully cannulated without untoward effects. All the attempts at placement of the filter were successful, and none were noted to be malpositioned. Postinsertion anticoagulation therapy was used in one patient with a Bird's Nest filter, in two patients with Greenfield filters, in four with Simon Nitinol filters, and in four with VenaTech filters.

Table IV. Deep venous thrombosis after vena caval filter insertion

Involved veins	*No. of patients*
EIV only	1 (7%)
EIV and CFV	1 (7%)
EIV/CFV/SFV/popliteal	4 (29%)
CFV/SFV/popliteal	5 (36%)
SFV and popliteal	2 (14%)
SFV only	1 (7%)
TOTAL	14 (100%)

EIV, External iliac vein; *CFV,* common femoral vein; *SFV,* superficial femoral vein.

The mean time from filter insertion to follow-up venous duplex scan examination was 12.0 ± 2.4 days, with a range of 0 to 50 days and a median of 6 days. There were a total of 14 patients with new proximal DVT ipsilateral to the filter insertion site, which was not present on the pre-insertion duplex scan study, for an overall incidence rate of 40%. The majority of thrombi (71%; 10 of 14) occurred in the common femoral vein. Most patients also had extension of thrombus either distally into the superficial femoral and popliteal veins or proximally into the external iliac vein (Table IV). Six patients had associated thrombosis of the greater saphenous vein. Of the 39 involved venous segments, 85% had occlusive thrombus and the remainder, mostly in the common femoral and external iliac veins, had non-occlusive

Table V. Ipsilateral deep venous thrombosis after filter insertion

Vein segments	*No. of veins*	*Occlusive*	*Non-occlusive*
External iliac	6	4	2
Common femoral	10	7	3
Superficial femoral	12	11	1
Popliteal	11	11	0
Total	39	33 (85%)	6 (15%)

Table VI. Deep venous thrombosis location after insertion

Vein	*Right*	*Left*	*No. of veins*
External iliac	6	8	14 (11%)
Common femoral	12	12	24 (19%)
Superficial femoral	13	18	31 (25%)
Popliteal	12	13	25 (20%)
Calf	10	7	17 (14%)
Superficial/GSV	7	7	14 (11%)
Total (%)	60 (48%)	65 (52%)	125 (100%)

GSV, Greater saphenous vein.

DVT (Table V). There were no differences between the occlusive and non-occlusive groups in terms of postprocedural anticoagulation therapy or time interval for follow-up duplex scan evaluation.

Three of the 14 patients with postinsertion DVT had had either an ipsilateral superficial femoral (one patient) or popliteal vein (two patients) thrombosis before filter placement. These patients subsequently had common femoral (n = 1), superficial and common femoral (n = 1), and superficial/common femoral/external iliac venous thrombosis (n = 1) develop. If these patients were excluded from consideration, the completely de novo thrombosis rate would be 31%. All of the other patients had only contralateral DVT present before caval filter placement. The total number of patients with proximal DVT, on either side, was 24 (69%) as compared with 19 (54%) before intervention. The bilateral proximal DVT rate increased from 5% (1 of 19) to 53% (11 of 24) after filter insertion ($P < .01$). The overall segmental distribution of thrombi changed accordingly, reflecting a more proximal preponderance of DVT within the external iliac and common femoral veins and a greater number in the right lower extremity (Table VI).

There was a significant correlation between the incidence of insertion side thrombosis and the type of vena cava filter. Of the filter types that had more than two inserted, the Greenfield filter had the smallest incidence of thrombosis and the Simon Nitinol had the highest incidence (Table VII). Interestingly, the two larger filters with a diameter of greater than 10F (Greenfield and Bird's Nest) had a significantly lower rate of thrombosis than did the smaller diameter filters (Simon Nitinol and VenaTech; 20% vs 55%; $P < .05$). Patients referred to the vascular laboratory after insertion of a caval filter because of ipsilateral lower extremity symptoms had a significantly higher probability of having DVT on that side (86%; 6 of 7) as compared with patients with contralateral symptoms (25%; 2 of 8; $P < .05$) or patients who were asymptomatic and returning for a routine follow-up examination (8%; 1 of 12; $P < .005$). Patients whose indications for a duplex scan examination were not clearly specified in the laboratory records and who may have possibly been symptomatic also had a high incidence rate of DVT (63%; 5 of 8).

Table VII. Filter type and insertion site thrombosis

Filter type	*No. of patients*	*No. of patients with DVT*	*Percent*
Greenfield	13	3	23%
Stainless steel	11	2	18%
Titanium	2	1	50%
Simon Nitinol	11	7	64%
VenaTech	9	4	44%
Bird's Nest	2	0	0%
TOTAL	35	14	40%

DVT, Deep venous thrombosis.

Although the highest incidence of thrombosis occurred in patients with pre-insertion PE (50%; 8 of 16) as compared with those with DVT (38%; 6 of 16) and prophylactic insertion (0%; 0 of 3), the subgroups were too small to attain statistical significance. The follow-up times were longer for the patients who were found to have DVT as compared with those patients who did not (16 ± 4 versus 9 ± 2 days), although this did not reach statistical significance ($P = .07$). Three of four patients with carcinoma had insertion site thrombosis, all having undergone treatment with a Greenfield filter. There were no significant differences in the use of postoperative anticoagulation therapy among the filter types. There were also no differences, either just after filter insertion or at the time of later duplex scan examination, in the prothrombin time, the international normalized ratio, or the partial thromboplastin time between the patients who had postinsertion DVT develop and those who did not.

DISCUSSION

Venous thromboembolic disease, manifested as either DVT or PE, is a significant clinical problem. Together, DVT and PE are responsible for more than 600,000 hospitalizations and 150,000 deaths yearly.[5-9] Patients with PE have a 3-month mortality rate of 18%, and those with only DVT have a 1-year mortality rate of 21%.[10] Inferior vena caval filters are as much as 97% effective for the prevention of PE and maintain a 95% caval patency rate.[1,2,11] According to industry sources, approximately 40,000 filters are inserted annually in the United States.[12] The accepted indications for filter placement include contraindications to conventional anticoagulation therapy in patients with either DVT or PE, extension of DVT or recurrent PE despite adequate anticoagulation therapy, complications of anticoagulation treatment, and prophylactic placement in patients at high risk for thromboembolic disease.[13] Our indications for filter insertion were similar to those reported by others, with more than three quarters of our patients undergoing treatment because of contraindications to anticoagulation therapy and only 9% prophylactically because they were at high risk for PE (Table I).[12,14-16] Similarly, about half of our patients had DVT (Table II), and most of the remaining patients had PE, either alone or in combination with DVT.

Within the past decade, it has been proposed that prophylactic vena caval interruption be more widely used, especially in trauma patients, both because of their high risk for thromboembolic complications and because anticoagulation therapy is frequently contraindicated in such circumstances. Khansarinia et al,[3] along with others, found that the Greenfield filter effectively prevented both PE and PE-related deaths in trauma patients at high risk and recommended its use.[13,17] However, a recent study by Decousus et al[4] has questioned the long-term benefits of vena caval filters. In a multicenter trial of 400 patients with proximal DVT, half were randomized to receive heparin anticoagulation therapy and the others underwent vena caval interruption with a variety of filters. Although the patients who had filters implanted had an initial reduction in PE (1.1% as compared with 4.8%), this difference lost statistical significance at 2 years (3.4% vs 6.3%) and was offset by a higher recurrence rate of DVT in the filter group (20.8% vs 11.6%; $P = .02$). On this basis, the investigators cautioned against the use of caval filters in this patient population. The authors mentioned that this increase in DVT recurrence could have been related to thrombosis at the filter insertion site, but such specific information was not available from their report. If, as in our study, the DVTs that were seen within the first 3 months were associated with venous thrombosis at the filter insertion site, their prevention would have eliminated the long-term DVT disadvantage ascribed to the caval filters (15% vs 12%; $P = .42$) and maintained beneficial protection against PE.

The initial experience with the percutaneous placement of caval filters showed a high incidence of insertion site thrombosis. Pais et al,[18] in a series of 24 patients with the original 24F Greenfield filter (29.5F sheath outer diameter), documented by ultrasound common femoral vein thrombosis related to filter placement in 33% of patients at a mean of 14 days, although less than one third of the patients were symptomatic. In another series, with venography at follow-up of 5 to 8 days, 41% of 17 patients had thrombosis of the common femoral vein, half of whom were symptomatic.[19] Mewissen et al[20] had a 19% incidence rate of thrombosis in 47 patients at 24 hours after insertion of the Greenfield filter, although less than half of the patients were symptomatic during the first month. Dorfman et al[21] found 14% to have complete thrombosis and another 19% to have venous "abnormalities" noted on ultrasound scanning. This early experience documented both the high incidence of insertion site thrombosis and that more than half of such patients were asymptomatic. It was hoped that, with the introduction of smaller carrier systems and other technical innovations, the occurrence of such DVTs would diminish.[20]

This goal does not, however, seem to have been achieved. Although symptomatic insertion-site DVT was reported in only 2% of almost 1436 patients from collected series with the newer filters, few of these reports reflect regular surveillance to detect subclinical asymptomatic occurrences.[2] In the initial series from Greenfield et al[15] that evaluated the newer titanium filter with a much smaller, 14F outside diameter sheath, 30 patients were seen at a mean of 5 months after filter insertion. DVT was documented in only two patients (7%) at the insertion site, although it is unclear whether all the patients underwent a complete duplex scan examination of the insertion site regardless of symptoms. Patton et al[17] documented a 9% incidence rate (3 of 33) of symptomatic in-hospital insertion site thrombosis when the titanium Greenfield was placed prophylactically in trauma patients at high risk. Harris et al[22] found an 18% incidence rate (4 of 22) of phlegmasia cerulea dolens in patients who had the titanium filter placed via the femoral approach at a mean of 5 days after filter inser-

tion. When the patients were followed with ultrasound scan examination independent of symptoms, Molgaard et al[14] found a 38% incidence rate (5 of 13) of either occlusive or non-occlusive thrombus in the common femoral vein, and Ferris et al[16] found a 30% incidence rate (6 of 20) of thrombosis in patients who were symptomatic. These results are consistent with our experience and a 23% incidence rate of DVT ipsilateral to Greenfield filter insertion at a mean follow-up period of 7 days (Table VII).

We had no thrombosis with the next largest filter, the Bird's Nest, although with only two patients in this series no statistical comparisons can be made. Other investigators, however, have reported an incidence of DVT similar to that of the Greenfield filter. Ferris et al[16] found a 17% incidence rate (7 of 42) of thrombosis in patients who were symptomatic. With routine follow-up ultrasound scanning, Molgaard et al[14] noted a 33% incidence rate (4 of 12) of DVT, and Hicks et al[23] documented 21% (10 of 48) of patients to have either complete or partial occlusion at the insertion site within 11 days.

The two smallest filters in our experience had a worse combined outcome as compared with the larger Greenfield and Bird's Nest filters (55% vs 20%). We found a 44% ipsilateral DVT rate with the VenaTech filter. Although Millward et al[24] reported only a 6% thrombosis rate, their report does not specify whether all patients were studied with duplex ultrasound scan after insertion, with what frequency they were followed, or when the thrombosis was discovered. More consistent with our findings, Ferris et al[16] noted a 32% incidence rate (8 of 25) of thrombosis in patients who were symptomatic, and Molgaard et al[14] reported a 34% incidence rate (12 of 35) on routine ultrasound scan follow-up examination. Similarly, Murphy et al[25] documented a 23% incidence rate (8 of 35) of thrombosis, detected with either duplex ultrasound scanning or venography. These results were not significantly different from what they had found with the original Greenfield filter.[21]

Although by far the smallest in both the diameter of the filter and the outer diameter of the sheath, the Simon Nitinol 7F filter had a 64% incidence rate of DVT ipsilateral to the filter insertion site. In two small series, one series showed symptomatic DVT in two of 16 patients (13%) who had filters placed through the femoral approach,[26] and another series found an 11% incidence rate (1 of 9) in patients who were symptomatic.[16] In the original series from Simon et al,[27] however, when duplex ultrasound scanning was prospectively performed in 18 patients after nitinol filter placement, insertion site thrombus was found in five (28%) of these patients. We have found no other reports that examined insertion site thrombosis with the nitinol filter. At the very least, although we also report on a small series of patients, it does not appear that its small size has been associated with a decreased risk of subsequent insertion site thrombosis.

Recurrent DVT at the insertion site may be caused by endothelial and intimal injury from the percutaneous placement of the filters followed by thrombus formation during relative venous stasis while extrinsic compression is applied. This theory is supported by the finding that most of the thrombi that develop are located at the most frequent sheath entry site, the common femoral vein, with both proximal and distal thrombus extension possible (Table IV). With proximal venography, Kantor et al[19] showed all these early thrombi to be located at the common femoral and iliac veins. Local intimal injury does not necessarily lead to complete thrombosis of the involved vein. Non-occlusive thrombi may develop, as was seen in 15% of our patients (Table V), which was consistent with the findings of others.[14] The hope that less intimal injury, and associated thrombotic complications, would occur with smaller delivery systems warrants continuing observation. However, the high rate of thrombosis even with the smallest Simon Nitinol filter suggests that this alone is not the only important variable.

Other likely contributing factors are the hypercoagulable states that are invariably present in these patients and that are the underlying pathophysiologic derangements requiring the placement of vena caval filters. It is prudent to continue anticoagulation therapy after filter insertion in patients who do not have a definite contraindication. All of the patients in the study from Harris et al[22] in whom phlegmasia developed after vena caval filters had not been undergoing anticoagulation therapy, suggesting to these investigators that anticoagulant therapy should be continued if at all possible.[22] Most of the patients in the study from Kantor et al[19] with later thrombosis (5 of 7) did not undergo anticoagulation therapy after filter insertion. Patients with an underlying malignant disease may be at higher risk for later insertion site thrombosis.[14] Although previous investigators have failed to establish a significant difference in the incidence of insertion site thrombosis between patients with and without postprocedural anticoagulation therapy, the ability to achieve statistical significance is limited by the small number of patients at individual institutions. In our examination of the surrogate markers for anticoagulation therapy, the laboratory coagulation profiles, we similarly could not

establish a relationship between anticoagulation therapy and later DVT development, although our study also suffered from the limitation of a small number of patients in each group. Nonetheless, we recommend that whenever possible anticoagulation therapy be continued both to control the underlying prothrombotic state and to decrease the prevalence of later insertion site thrombosis.

Along with the systemic hypercoagulable state, local venous conditions may also predispose to later insertion site thrombosis. Caval occlusion could diminish venous flow and increase distal venous pressure, leading to a higher incidence of lower extremity DVT. The presence of proximal vein partial thrombus, either in the iliac or vena cava, or the extrinsic compression of these veins have been associated with a higher incidence of later insertion site thrombosis.[14] For this reason, either the contralateral femoral vein or a jugular approach should be used when non-occlusive thrombus is found in the ipsilateral iliac vein or vena cava, respectively. Although other investigators have espoused a contrary view,[20] the presence of distal thrombus in the superficial femoral or popliteal veins may also predispose to later DVT development. In three of our patients, thrombi in these segments extended to involve the common femoral vein after filter insertion. Therefore, although not precluding the safe technical insertion of the filter through the femoral approach, consideration should be given to an alternative access site in these situations. The right common femoral vein is technically easier to use for right-handed individuals and is a straighter venous segment than the left. Mewissen et al[20] found the left femoral vein to be associated with a higher morbidity and recommended that the right side be preferentially used. Molgaard et al[14] found no significant differences in insertion site thrombosis between the right and left common femoral veins. With the present smaller diameter and more flexible filters, the left femoral approach is acceptable if needed because of other considerations.

Almost all of the present literature that deals with insertion site thrombosis has described this as a complication of the femoral approach. The original insertion site of the Kimray-Greenfield filter was via the jugular approach.[28] This route did not attain popularity because of the risks of pneumothorax and inadvertent carotid arterial puncture associated with that site. However, because of the puncture-site complications of the femoral approach, Kantor et al[19] have suggested the jugular approach be preferentially be used in patients with a long life expectancy. Similarly, to diminish the long-term morbidity of venous insufficiency, Greenfield[29] has suggested the jugular route as possibly the preferred technique in young trauma patients. To prevent the later development of phlegmasia cerulea dolens in patients who require vena caval interruption and cannot undergo anticoagulant therapy, Harris et al[22] recommended the consideration of the jugular access site as a better alternative. Crochet et al[30] routinely prefer the right internal jugular vein for all caval filters. There is currently not enough information concerning insertion site thrombosis of the internal jugular vein to definitively recommend it as the preferred route for vena caval filter placement over the femoral vein. It is advantageous in a number of circumstances, however. A prospective randomized trial that would compare the two sites would be worthwhile.

CONCLUSION

There is a continuing and significant incidence of new DVT development ipsilateral to the percutaneous femoral insertion site of vena caval filters. The risk of insertion site thrombosis has not been eliminated with the use of the smaller diameter filters and sheaths. The higher thrombosis rate seen in our experience with the smaller filters suggests that other variables beyond filter size are important in the later development of DVT. Anticoagulation therapy should be continued after vena caval filter insertion unless definite and continuing contraindications exist to prevent its use. Partial venous thrombosis proximal or distal to the common femoral vein increases the risk of postinsertion DVT. The internal jugular vein may be a better access site for vena caval filter insertion.

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DISCUSSION

Dr Lazar J. Greenfield (Ann Arbor, Mich). Congratulations to Dr Blebea and his associates on what I believe is a timely study. I also want to express my thanks for the opportunity to review their manuscript.

The problem of recurrent DVT after filter placement was brought into a high level of concern recently by the report of Decousas, as mentioned by the authors, and this has been widely accepted despite serious flaws in the design and analysis of their filter patient population. As a result, many physicians now are afraid to discontinue anticoagulant therapy long term for fear of recurrent venous thrombosis in patients with filters. Dr Blebea and his colleagues have reviewed their experience with patients who have received filters inserted by either surgeons or radiologists during a 5-year period and who had follow-up duplex scan examinations. Unfortunately, only 13% of their filter patients fulfilled the entry criteria. So, my first question is whether this group was truly representative of the entire population or whether there is potential adverse selection of symptomatic patients who were referred for duplex scan study. It is clear that the surgeons were routinely performing duplex scan follow-up examinations 1 week after insertion, but because only 20% of the insertions, or seven patients, had filters placed by surgeons, the largest number were in fact treated by radiologists and their method of follow-up examination is not stated.

One of the fundamental problems in assessing insertion site venous thrombosis is the lack of definition of the extent of thrombosis found. The variables affecting this include the size of the vein puncture, the duration of sheath placement, and the extent of manual compression on the vein after the sheath is removed. Do the authors have any idea of how these variables might have affected their results? The authors did indicate that 85% of the thrombi were occlusive and 15% were non-occlusive. The obvious question is whether there were any differences in the two groups, such as the protocol

for postprocedure compression, the use of postprocedure anticoagulation therapy, or the time interval to the study allowing for some thrombus resolution or recanalization. It is interesting that the sheath size seemed to have an inverse correlation with thrombosis, and I wonder if the authors have any thoughts about the reason for this.

When we recently reviewed our own database of 1191 patients with acute DVT who had filter placement, 488 of them had undergone anticoagulation therapy after placement and 639 had not. We had follow-up data for 465 patients, and they showed a very similar 12% incidence rate of new DVT, which was independent of whether or not the patient underwent anticoagulation therapy. In fact, the only positive correlation was found in patients with cancer with an increased risk of recurrent DVT. However, the failure of anticoagulation therapy to protect against DVT in these prothrombotic patients should not argue against its use where possible because the ability to prevent further propagation of existing DVT is important in minimizing the risk of phlegmasia cerulea dolens and in reducing the severity of the post-thrombotic syndrome.

In bringing this subject to our attention, the authors have challenged us to reexamine the technical aspects of filter insertion to reduce this complication. Their suggestion of a trial comparing jugular with femoral insertion is certainly worth consideration, and I believe that other innovative approaches, such as using ultrasound scanning for bedside placement and perhaps eliminating external compression after sheath removal as suggested by Dr Kyung Cho in our own radiology department, will add to the safety and cost effectiveness of filter placement.

Thank you for the opportunity of commenting on this excellent paper.

Dr John Blebea. Thank you, Dr Greenfield, for your comments and insightful discussion. Only a minority of all patients receiving vena caval filters had postoperative duplex scanning performed and were therefore included in this report. Although all the surgical patients had such subsequent scans done routinely, only seven of the 35 patients (20%) had venous studies performed because they were documented to be symptomatic with leg pain or swelling. Nonetheless, there is probably a negative selection bias in such a retrospective study, and the true incidence of postinsertion DVT would best be answered with a prospective study.

The duration of sheath placement and the extent of manual compression on the vein were neither measured nor reported, and their effect on subsequent DVT development is unknown. We examined the use of anticoagulation therapy, as reflected by the prothrombin time, the international normalized ratio, and the partial thromboplastin time, both at the time of the initial filter insertion and at the follow-up evaluation. In this small group of patients, there were no significant differences in these values between patients with and without subsequent DVT development.

Non-occlusive thrombi were most frequent in the common femoral and external iliac veins. This suggests that these thrombi are caused by intimal injury during sheath insertion, which, for unknown reasons, does not progress to complete occlusion. The relatively early follow-up venous scans in these patients, and their ultrasonic characteristics, suggest that these are initial non-occlusive thrombi rather than chronic recanalized thrombi.

Our finding that smaller diameter filters were not associated with a decrease in the incidence of DVT indicates that other clinical variables are more important risk factors for later thrombus development. Identifying and modifying such risk factors, or reexamining alternative insertion sites, remains a challenge for the future.